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Food Products Containing Texturized Milk Proteins

Background Of The Invention

[0001] The present invention relates to a dietary fiber composition produced by a process involving extruding a milk containing product (e.g., milk, milk concentrate, whey, whey concentrate, whey protein isolate) through an extruder at about 50-about 400 rpm and at a temperature of about 50° to about 120°C to produce the dietary fiber composition. The present invention also concerns a fiber enriched food product containing at least one food ingredient and the dietary fiber composition described herein. In addition, the present invention relates to a method of making a fiber enriched food product, involving adding the dietary fiber composition described herein to one or more food ingredients or adding one or more food ingredients to the dietary fiber composition described herein. Furthermore, the present invention concerns a method of increasing fiber in the diet of a mammal, involving feeding to the mammal the fiber enriched food product described herein.

[0002] As the reports of the health and nutraceutical benefits of consuming dietary fibers continue to grow, research is focused on increasing the amount, content and quality of fibers in human diet. Consumers as well as nutrition-focused professional organizations are demanding increased amounts of fiber in processed foods. The results of recent surveys of the amount of fiber consumed by Americans reveal that most consume less than 50% of the estimated desirable daily fiber intake. Current average fiber intake is estimated at about 12 g/day, but the American Dietetic Association recommends 20-35 g/day (J. Am. Dietetic Assoc., 93: 1446-1447 (1993)).

[0003] Foods rich in fiber help with the management of a host of conditions. Associated healthful benefits of increasing fiber consumption include reduced risk of some types of cancer (including breast cancer) and coronary heart disease, regulation of blood glucose and insulin, lowering the concentration of blood lipids, reduced risk of cardiovascular disease and controlling diabetes, alleviating constipation, hemorrhoids and diverticulitis (Wolk, A., et al., JAMA,

281(21): 1998-2004 (1999); Kritchevsky, D., Cereal Foods World, 42(2): 81-85 (1977)). Thus it is desirable and beneficial to increase the amount of fiber in most prepared foods.

[0004] The Food and Agricultural Organization/World Health Organization (FAO/WHO), 1995 Codex Alimentarius Commission defines dietary fiber as, "the edible plant or animal material not hydrolyzed by the endogenous enzymes of the human digestive tract as determined by the agreed upon method." Typical fiber sources are plant-based and include grains, fruits and vegetables; other less-traditional food fibers include Chitosan, a fat-binding dietary fiber derived from shellfish, and polymeric components such as cell-wall proteins and phenolic compounds such as tannin and cutin.

[0005] Traditionally, the food industry uses native (folded) whey proteins for their functional and nutritional properties in formulating different foods. Though new products incorporating whey proteins, such as sports drinks, are being developed, innovation in process and product development is still needed (Anon., American Dairy Products Institute, Bulletin No. 25, p. 17 (2000)). Fortifying snacks with whey proteins could provide a particularly attractive outlet for surplus whey proteins; however, this practice has been limited due to known adverse textural effects when the whey protein concentrate supplementation is greater than 10% of the main starch component (Kim, C. H., and J. A. Maga, Lebensmittel-Wissenchaft und-Technologie, 20: 311-318 (1987)).

[0006] The present invention provides proteins (e.g., whey proteins) that are totally texturized and are insoluble to enzymes and protein cleaving chemicals (e.g., urea). The new product is indigestible and can therefore serve as a fiber source. The fiber-like product described in this invention is from an animal source (e.g., milk), but its properties are physiologically similar to plant-source dietary fiber, thus serving as a bulking agent and being nondigestible to enzymes. Alternate use for this product include use in biodegradable products and utilization in ingredients that require low gelling temperatures.

Summary Of The Invention

[0007] The present invention relates to a dietary fiber composition produced by a process involving extruding a milk containing product (e.g., milk, milk concentrate, whey, whey concentrate, whey protein isolate) through an extruder at about 50-about 400 rpm and at a temperature of about 50° to about 120°C to produce the dietary fiber composition. The present invention also concerns a fiber enriched food product containing at least one food ingredient and the dietary fiber composition described herein. In addition, the present invention relates to a method of making a fiber enriched food product, involving adding the dietary fiber composition described herein to one or more food ingredients or adding one or more food ingredients to the dietary fiber composition described herein. Furthermore, the present invention concerns a method of increasing fiber in the diet of a mammal, involving feeding to the mammal the fiber enriched food product described herein.

Brief Description Of The Drawings

[0008] Figure 1 shows electron micrograms of whey protein isolates (WPI): (A) scanning microscopy was used to examine dry powder; (B) the non extruded WPI Paste (40% moisture) was embedded, stained with uranyl acetate and sections examined by transmission electron microscopy; (C) extruded (100 °C) WPI (40% moisture) treated as in (B);

[0009] Figure 2 shows SDS PAGE of extruded whey isolates: (A) with 2-mercaptoethanol; (B) without 2-mercaptoethanol; the lanes are: 1 = 100 °C; 2 = 75 °C; 3 = 50 °C; 4 = 35 °C; 5 = Native WPI; 6 = laboratory whey;

[0010] Figure 3 shows transmission electron micrographs of whey protein isolates (WPI) positively stained with uranyl acetate and lead citrate: (A) enlargement of texturized whey as in Figure 1C; (B) enlargement of a selected protein-dense area of Figure 1B; (C) Fast Fourier

Transforms of electron density images of native WPI; and (D) Fast Fourier Transforms of electron density images of texturized WPI; and

[0011] Figure 4 shows electron-density mapping corresponding to the Fourier Transforms (A) for texturized and native WPI, and (B) inverse reciprocal spacing of electron-density images.

Detailed Description Of The Invention

[0012] The present invention relates to a dietary fiber composition containing completely texturized proteins. The dietary fiber composition is produced by a process wherein the proteins in a milk containing product (e.g., milk, milk concentrate, whey, whey concentrate, preferably whey protein isolate) are completely texturized. This process involves processing the milk containing product through an extruder (e.g., twin screw extruder) at low shear (generally about 50-about 400 rpm (e.g., 50-400 rpm), preferably about 50-about 300 rpm (e.g., 50-300 rpm), more preferably about 50-about 200 rpm (e.g., 50-200 rpm), most preferably about 50-about 100 rpm (e.g., 50-100 rpm) at a temperature of about 50° to about 120°C (e.g., 50° to 120°C, preferably about 90° to about 120°C (e.g., 90° to 120°C), more preferably about 95° to about 120°C (e.g., 95° to 120°C), most preferably about 100° to about 110°C (e.g., 100° to 110°C). Low shear increases the residence time of the milk containing product in the extruder since residence time is a function of the rpm of the extruder, the residence time can increase from 45 to 90 seconds. Pressures may range from about 500 to about 1500 psi (e.g., 500-1500 psi, preferably about 800 to about 1200 psi (e.g., 800-1200 psi)) and torque may range from about 30 to about 70% (e.g., 30-70%, preferably about 45 to about 55% (e.g., 45-55%)). The process may also utilize other proteins such as, for example, soy protein, vegetable protein, animal protein.

[0013] The present invention also concerns a fiber enriched food product containing at least one food ingredient and the dietary fiber composition. The food ingredient may be any food ingredient. For example, the food ingredient may be the ingredients for cookies or muffins such as flour. Furthermore, the food ingredient may be shelf-stable packaged pre-mixes for preparing

food and beverage compositions, usually requiring the addition of other ingredients (e.g., eggs, shortening, water or milk) to be supplied and added by the preparer. Additionally, the food ingredient may be a ready-to-cook mix (combined food ingredients that require additional cooking (e.g., baking, frying, micro waving) to form a ready-to-eat food or beverage product). Generally, the fiber enriched food product may be any food product such as a drink, yogurt, or pizza, or a bakery product such as cake, biscuit, pie crust, cookie, muffin, bread, cereal, doughnut, noodle, brownie, cracker or snack food. The amount of the dietary fiber composition contained in the fiber enriched food product may be any amount that does not adversely affect the food product (for example, the fiber enriched food product may contain about 1% to about 40% of the dietary fiber composition, preferably about 5% to about 30%, more preferably about 5% to about 20%, most preferably about 10% to about 15%).

[0014] The texturized proteins of the present invention can be added to baked sweet wafers to offer another type of protein enrichment to cookies or snack bars. It may also be possible to utilize the texturized proteins of the present invention in meal extenders and meat alternatives, function as instant thickeners for beverage and dairy applications, and also finding use as edible films and encapsulating agents. The texturized proteins of the present invention may also function as an instant thickening product which can be used in place of starch and other hydrocolloids; potential applications include baby food, sports drink and dairy foods such as sour cream, yogurt and cottage cheese.

[0015] The possibilities for texturized proteins of the present invention extend past the grocery aisle. The texturized proteins of the present invention may make oxygen, aroma and oil barrier films at low-to-intermediate relative humidity; may provide mechanical properties and adequate functionality when used as coating or encapsulating agents, providing durability when applied directly on foods or as films when separating layers of heterogeneous foods, or films formed into pouches for food ingredients; and may also be used as encapsulating agents.

[0016] Additionally, the present invention also relates to a method of making a fiber enriched food product involving adding the dietary fiber composition to one or more food ingredients (or vice versa). For example, in making cookies or muffins, the dietary food composition can partially substitute for flour or be added in addition to flour in the preparation of cookies or muffins. If cooking (e.g., baking, frying, micro waving) is required, then normal cooking conditions are utilized.

[0017] Furthermore, the present invention concerns a method of increasing fiber in the diet of a mammal involving feeding to the mammal the fiber enriched food product described herein. Generally, the mammal is a human.

[0018] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention belongs. Although any methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, the preferred methods and materials are now described.

[0019] The following examples are intended only to further illustrate the invention and are not intended to limit the scope of the invention as defined by the claims.

Examples

Materials And Methods:

[0020] Whey protein concentrate (ALACEN 834) and lactalbumin (ALATAL 825) were purchased from New Zealand Milk Products, Inc. (Santa Rosa, CA). Whey Protein Isolate (PROVON 190) was purchased from Glanbia Ingredients. The compositions were as follows: WPC80 (whey protein concentrate, 80% protein), moisture 2.8%, protein 83.6%, fat 0.8, ash 3.3%, carbohydrate by difference; WLAC (whey lactalbumin), moisture 5.5%, protein 89.9%, fat 3.8, ash 0.5%, carbohydrate by difference; Whey Protein Isolate (WPI), moisture 2.8%, protein 89.6%, fat 25, ash 3.3%, carbohydrate by difference.

[0021] A ZSK-30 twin screw extruder (Krupp Werner Pfleiderer Co., Ramsey, NJ) with a smooth barrel was used. The extruder had nine zones, and the effective cooking zones 6, 7, 8, and 9 were set to the same temperature for each test. To achieve different melt temperatures the cooking zones were set to the same barrel temperature of 35, 50, 75, or 100 °C respectively. Zones 1 to 3 were set to 35 °C and zones 4 and 5 were set to 75 °C. Melt temperature was monitored behind the die. The die plate was fitted with two circular inserts of 3.18 mm diameter each. The screw elements were selected to provide low shear at 300 rpm; the screw profile was described by Onwulata et al. (Onwulata, C.I., et al., J. Food Sci. Vol., 63(5): 814-818). Feed was conveyed into the extruder with a series 6300 digital feeder, type T-35 twin screw volumetric feeder (K-tron Corp., Pitman, NJ). The feed screw speed was set at 600 rpm, corresponding to a rate of 3.50 kg/h. Water was added into the extruder at the rate of 1.0 L/h with an electromagnetic dosing pump (Milton Roy, Acton, MA). Samples were collected after 25 min of processing, freeze-dried overnight in a VirTis Freeze Mobile 12XL Research Scale Freeze Dryer (Gardiner, NY), and stored at 4.4 °C until analyzed. The experiments were performed in triplicate.

[0022] Analysis of variance was used to identify differences in physical properties at various processing conditions. Duncan's multiple range test was used for mean separation and correlation coefficients were calculated. The Statistical Analysis System (SAS) package was used (SAS Institute Inc, Cary, NC) in all cases. Significance of differences was defined as $P \leq 0.05$.

[0023] Moisture was determined by the AOAC (Association of Official Analytical Chemists) Official Method 925.10. Extrudate samples weighing approximately 1.5 g were dried in a vacuum oven at 100 °C overnight (AOAC, 2000, Official Methods of Analysis, 14th ed., Association of Official Analytical Chemists, Washington, DC).

[0024] Ash was determined by the AOAC Official Method 923.03. Ash was determined for each sample using 3 g assayed in a Muffler furnace at 550 °C for 16 h; percent ash was calculated.

[0025] Fat was determined using the AOAC Official Method 30-25. One gram extrudate sample was placed in an Erlenmeyer flask and 1 ml of sulfuric acid and 4 ml water was added to the flask. The samples were mixed gently and after 60 min were transferred to a 60 ml separatory funnel using 25 ml of dichloromethane : methanol solution (1:1). Extrudate samples were shaken and allowed to separate for 15 min. The bottom layer was drained into a weighing pan and then evaporated, and the amount of fat determined (American Association of Cereal Chemists, 1995, Approved Methods of the American Association of Cereal Chemists, 9th Edition., The Association, St Paul, MN).

[0026] Protein was determined with 0.2 g extrudate analyzed with the LECO Protein Analyzer Model FP2000 (LECO Corporation, St. Joseph, MI). Percent protein was calculated with the nitrogen conversion factor 6.38 for whey protein.

[0027] Gel strength was measured by Bloom determinations with a TA-XT2 Texture Analyzer (Ju, Z. Y., and A. Kilara, J. Food Sci. 63(2):288-292 (1998)). A 12% WPI solution was made (3.204 g of ground freeze-dried sample mixed with 26.7 ml deionized water and 3.3 ml 0.03 M $CaCl_2$), and allowed to sit for 15 min in a 50 x 70 mm cylindrical jar. The sample was heated to 80 °C for 30 min in a water bath, cooled in an ice bath for 15 min and then stored overnight at 4°C. The specimen was thawed at 25°C in 50% relative humidity room. Gel strength was determined with a TA-XT2 Texture Analyzer running a penetration test with a 30 mm analytical probe to a depth of 6 mm at the rate of 1 mm/sec. The weak gels were easily deformed with evidence of syneresis.

[0028] Protein insolubility was determined with 1.0 g ground freeze-dried extrudate sample mixed with 90 ml deionized water. The protein suspension was stirred at 125 rpm at pH 7.0 for 2 h. The suspension was centrifuged for 20 min and the supernatant was freeze dried overnight.

The LECO Protein Analyzer Model FP2000 (LECO Corporation, St. Joseph, MI) was used to analyze the solids from the supernatant for protein content. Protein insolubility (denaturation) was calculated (Kilara, A., J. Dairy Sci., 67:2734-2744 (1984)) as: (% Total Protein - % Soluble Protein = % Insoluble (denatured)).

[0029] Foam volume and stability of extruded proteins were determined by heating 2.3 g samples mixed with 35 ml deionized water to 60 °C for 15 min. The slurry was then whipped for 15 sec in Waring Lab Micronizer FPC70 (Waring Products Division, New Hartford, CT), then transferred to a 100 ml graduated cylinder where the foam volume was read initially, and then every 5 min for 1 h. Foam stability (foam capacity at specific time) over the one hour period was calculated.

[0030] Protein Digestibility was determined with 10 ml extrudate sample dissolved in distilled water, the pH was adjusted to 8.0 with 0.1 N NaOH or HCl. One milliliter of freshly prepared enzyme stock solution (1.6 mg/ml trypsin, 3.1 mg/ml chymotrypsin, and 1.3 mg/ml aminopeptidase) was added to the protein suspension at 37 °C. The pH after 10 min was recorded with a portable pH meter (IQ Scientific Instruments, Inc. San Diego, CA), and a Tris/HCl buffer containing 2.0% SDS (w/v) and 0.1% mercaptoethanol (v/v) was added to the protein solution which was immediately heated to 90 °C to terminate the enzymatic reaction. Samples were then analyzed by quantitative gel electrophoresis. The % protein digestibility was calculated by the following equation (Ju, Z. Y., and A. Kilara, J. Food Sci. 63(2):288-292 (1998)): % Digestibility = 210.46 B 18.10(X); where X is the pH .

[0031] For SDS PAGE assay, samples were vortexed and dissolved in 20 mM TRIS/HCl, 5 mM EDTA, 2.5% SDS with and without 5.0% 2-mercaptoethanol at pH = 8.0 then heated in boiling water for 2 min. Bromophenol blue is added to about 0.1% concentration. The samples were at 2 mg/ml concentration. Phast gels (Amersham Pharmaica Biotech, Uppsala, Sweden) were run according to the procedures given by the manufacturer for SDS 20% homogeneous gels. The 6

lane (4 ul per lane) sample applicators were used. Protein staining used the coomassie blue procedure given by the manufacturer (Farrell, H., E. D., et al., J. Dairy Sci., 81:2974-2984 (1998)).

[0032] For fine structure, transmission electron microscopy (TEM) was done of thin sections made from epoxyembedded samples. Millimeter-sized pieces of coarsely ground, freeze-dried segments of ribbons of the extrudates were immersed in 2.5% glutaraldehyde in 0.1 M imidazole buffer solution (pH 6.8) and stored in sealed vials at 4 °C. For embedding and thin sectioning, the segments were washed in imidazole buffer, immersed in 2% osmium tetroxide in 0.1M imidazole buffer for 2 h at room temperature, washed in distilled water, and gradually dehydrated in a series of ethanol solutions and propylene oxide for one hour. Samples were then infiltrated with a 1:1 mixture of propylene oxide and epoxy resin mixture overnight and finally embedded in epoxy resin. Thin sections were cut and stained with 2% uranyl acetate, and lead citrate solutions. TEM was done in the bright field mode using a model CM12 electron microscope (FEI/Philips, Hillsboro, OR). Average spacings of electron density, corresponding to fine structure in the extrudates, were estimated from the intensity distribution in Fourier transforms, computed from digital images made from TEM photographic negatives, recorded at 45,000X. Negatives were digitized using a SprintScan 45 film scanner (Polaroid Corp., Cambridge, MA) and square areas of 2.8 megabyte images (512 × 512 pixels) were transformed after flattening, adjustment of brightness and contrast and one cycle of a low pass filter using a 3 H 3 pixel kernel in Image Pro Plus software (Media Cybernetics, Silver Spring, MD). Line profiles of the radial distribution of intensity in the Fourier transforms were made, and reciprocal spacings were calculated based on the location of orders of peaks in transforms of a line grating with an equivalent spacing of 22 nm.

[0033] For scanning electron microscopy (SEM), a layer of dry powder particles was adsorbed onto conductive carbon adhesive tabs glued to aluminum specimen stubs (Electron Microscopy Sciences, Ft. Washington, PA), and the surface was coated with a thin layer of gold in a model

Scancoat Six sputter coater (BOC Edwards, Wilmington, MA). Images of the powder particles were made with a model JSM 840A scanning electron microscope (JEOL USA, Peabody, MA) operating in the secondary electron imaging mode and integrated with a digital image workstation, model Imix1 (Princeton Gamma-Tech, Princeton, NJ).

Results And Discussion:

[0034] Extruding whey proteins at the preset temperature of 75 °C resulted in varying degrees of melt temperatures and texturization for the different products (Table 1; % is percent of texturized proteins). Following extrusion, whey protein concentrate (WPC80) was the least texturized, and whey lactalbumin (WLAC) and whey protein isolates (WPI) were significantly ($p<0.05$) more texturized. WPI demonstrated the greatest effect, changing from 28 to 94.8% texturized. Therefore, further experiments were conducted with WPI.

[0035] The effect of extrusion cooking on texturized proteins was examined by electron microscopy. Changes in the microstructure of WPI and the ultrastructure of the texturized proteins are presented in Figure 1. The microstructure of the dry powders, examined by scanning electron microscopy, reveal particles ranging from 10 to 50 micrometers in diameter (A). Transmission electron microscopy (B) shows the release of protein at the edge of powder particles after brief exposure to water typical of initial mixing in the extruder; irregular strings and granules, corresponding to molecular aggregates, ranging from less than 10 nm to over 200 nm can be seen (B). In contrast, the ultrastructure of extruder-texturized insoluble whey protein shows a closely-packed arrangement of electron dense particles, typical of texturized protein matrix, ranging from approximately 2 to 6 nm in diameter (C).

[0036] With the addition of shear in the extruder, significant unfolding (texturization) occurred at 75 °C. WPI extruded at preset temperatures at or above 50 °C texturized significantly ($p<0.05$) with increased preset temperature. The pH of the suspended protein remained stable as extrusion temperature increased, but measurable nitrogen (protein) increased as shown in Table 2. Loss of

protein nitrogen might be expected as temperatures increased above 80 °C, but we surprisingly observed no significant change in protein nitrogen content after drying. Though the amount of protein texturized increased, with increasing temperature, texturization had minimal overall effect on protein digestibility. So the surprising result is increased protein texturization without a significant loss of digestibility due to extrusion below 100 °C.

[0037] The WPI and variously heat treated samples were compared by SDS-PAGE (Figure 2). SDS gel of the variously texturized WPI indicated minimal change in solubility (Figure 2). SDS gels were initially developed without reducing reagent so the protein disulfide bonds are intact. The unreduced samples at 35 °C and 50 °C show somewhat diminished bands for the higher molecular weight whey proteins (B). However, at 50 °C and 70 °C samples were equivalent weight, and fainter than the native whey or whey proteins produced in the lab on the SDS gel (compare lanes 1 and 2 with 6 in Figure 2). In this respect, the SDS gels parallel the solubility data in that increased temperature decreases solubility in SDS alone, indicating sulfhydryl-disulfide crosslinking. When the samples were reduced thoroughly and all disulfide bonds cleaved, all the extruded whey samples at the different temperatures were similar to each other and to the initial WPI (A). Thus, extruding whey even at the highest temperatures surprisingly does not affect the overall protein ratios. The native and extruded whey still have the same amount of the different proteins (Figure 2) and their total nitrogen values were similar (Table 2).

[0038] Physical functional properties of extruded WPI such as gel strength, foam volume and stability were significantly affected at and above 75°C, and proportionally at lower preset temperatures. Greater than 30% moisture was needed to extrude the whey protein isolates, but the only significant change in moisture of the extruded products occurred at 100°C (Table 3). Partial texturization at temperatures between 35 ° and 50°C significantly increased gel strength, but at 75 °C or higher complete loss of gelling property resulted. Foam volume remained high up to 50 °C, but decreased significantly ($p<0.05$) after 75°C. Foam stability followed the same

pattern as volume, being very stable for an hour below 50°C. However, with the addition of shear from the extruder, we observed significant loss of volume and stability.

[0039] Texturized whey protein isolate looks quite different from the non-texturized proteins at the ultrastructural level (Figure 3). As sampled, texturized proteins (3A) (WPI extruded at 100°C) are densely packed with spacing of 2 to 6 nm, while non-texturized whey in the paste are loosely packed with a large spacing 200 to 350 nm (3B). The differences in fine structure of texturized and native whey protein are illustrated in Figures 3 and 4. In the "native" whey protein (40% slurry), the distribution of electron density surrounding the hydrating particles in Figure 1B is an open network with clear, electron-lucent spaces ranging from 15-40 nm and irregular structures of electron density of similar dimensions. In contrast, the fine structure in segments where the whey proteins are completely texturized is limited to close-packed fine granules around 3-8 nm in diameter (Figure 3). The corresponding computed Fourier transforms indicate that images of extrudate containing native whey proteins consist mainly of low spatial frequencies indicating structures with average spacings ranging from 15 to over 40 nm, whereas images of extrudate containing texturized whey proteins have little intensity at low spatial frequencies, but high intensity corresponding to high spatial frequencies, relating to electron density changes ranging from about 3 nm to less than 10 nm (Figure 4). The constraint of extruding whey is keeping the temperature below the point where pyrosis will occur as evidenced by relatively constant nitrogen content (Table 2). We have seen evidence of fine structures with TEM images at 100 °C in whey isolates.

[0040] We have thus created structured networks in whey proteins using mild heat and shear, to create reversible texturized whey proteins. By understanding on a molecular basis the effects of shear, ways of creating new functionality can be developed. This will enable development of extrusion parameters that permit controlled texturization of whey proteins.

[0041] Extrusion processing texturized whey protein concentrates, whey lactalbumin (LAC) and whey protein isolate (WPI), but the greatest amount of texturizing occurred with WPI. Texturized whey protein isolate retained its native protein value, functionality, and digestibility when extruded at 50 °C or below; changes in functionality occurred at 75 and 100 °C. Through careful selection of extrusion conditions, texturized whey proteins with unique functionality were produced. Texturization increased with temperature, but temperatures higher than 100 °C may be needed to form texturized fibrous products from whey protein isolates. We show here that extrusion is an effective tool for texturizing whey proteins to create texturized products.

[0042] All of the references cited herein are incorporated by reference in their entirety. Also incorporated by reference in their entirety are the following references: Aboagye, Y., and Stanley, D.W., Can-Inst-Food-Sci-Technol-J., 20(3):148-153 (1987); Batterman-Azcona, S.J., and Hamaker, B.R., Cereal Chem., 75(2):217-221 (1998); Farrell, H. M., Jr., et al., J. Dairy Sci., 85(3):459-471 (2002); Hale, A. B., et al., J. Food Sci., 67(3):1267-1270 (2002); Harper, J.M., Extrusion of Foods, Vol. I., 1981, CRC Press, Boca Rotan, FL; Harwalkar, V. R., Michwissenchaft, 34(7):419-422 (1979); Hong, Y., and L. K. Creamer, Int'l. Dairy J., 12:345-359 (2002); Kim, C. H., and J. A. Maga, Lebensmittel-Wissenchaft und-Technologie, 20:311-318 (1987); Kester, J. J., and T. Richardson, J. Dairy Sci., 67(11):2757-2774 (1983); Kollengode, A.N., et al., J. Food Sci., 61(3): 596-599, 603 (1996); Martinez-Serna, M. D., and Villota, R., 1992, Reactivity, functionality, and extrusion performance of native and chemically modified whey proteins, pages 387-414 in Food Extrusion Science and Technology, J. L. Kokini, C. Ho, and M. V. Karwe, ed., Marcel Dekker, Inc. New York; Mohammed, Z. H., et al., J. Food Sci., 65(2):221-226 (2000); Kester, J. J., and T. Richardson, J. Dairy Sci., 67(11):2757-2774 (1983); Lin, S., et al., J. Food Sci., 67(3):1066-1072 (2000); Phillips, L. G., et al., J. Food Sci., 55(4):1116-1119 (1990); Singh, R. K., et al., J. Food Processing and Preservation, 15:285-302 (1991); Taylor, S.M. and Fryer, P.J., Food Hydrocoll., 8 (1):45-61 (1994); Walstra, P., T. J., et al., 1999, pages 189-199 in Dairy Technology: Principles of Milk

Properties and Processes, P. Walstra, T.J. Geurts, A. Noomen, A. Jellema, and M. A. J. S. van Boekel, ed., Marcel Dekker, Inc., New York.

[0043] Thus, in view of the above, the present invention concerns (in part) the following:

[0044] A dietary fiber composition produced by a process comprising (or consisting essentially of or consisting of) extruding a milk containing product through an extruder at about 50-about 400 rpm and at a temperature of about 50° to about 120°C to produce said dietary fiber composition.

[0045] The above dietary fiber composition, wherein said rpm is about 50-about 300 rpm.

[0046] The above dietary fiber composition, wherein said rpm is about 50-about 200 rpm.

[0047] The above dietary fiber composition, wherein said rpm is about 50-about 100 rpm.

[0048] The above dietary fiber composition, wherein said temperature is about 90° to about 120°C.

[0049] The above dietary fiber composition, wherein said temperature is about 95° to about 120°C.

[0050] The above dietary fiber composition, wherein said temperature is about 100° to about 110°C.

[0051] The above dietary fiber composition, wherein said process involves a pressure of about 500 to about 1500 psi.

[0052] The above dietary fiber composition, wherein said process involves a pressure of about 800 to about 1200 psi.

[0053] The above dietary fiber composition, wherein said process involves a torque of about 30 to about 70%.

[0054] The above dietary fiber composition, wherein said process involves a torque of about 45 to about 55%.

[0055] The above dietary fiber composition, wherein said milk containing product is selected from the group consisting of milk, milk concentrate, whey, whey concentrate, whey protein isolate, and mixtures thereof.

[0056] The dietary fiber composition, wherein said milk containing product is selected from the group consisting of whey concentrate, whey protein isolate, and mixtures thereof.

[0057] A fiber enriched food product comprising (or consisting essentially of or consisting of) at least one food ingredient and the above dietary fiber composition.

[0058] A method of making a fiber enriched food product, comprising (or consisting essentially of or consisting of) adding the above dietary fiber composition to one or more food ingredients or adding one or more food ingredients to the above dietary fiber composition.

[0059] A method of increasing fiber in the diet of a mammal, comprising (or consisting essentially of or consisting of) feeding to said mammal the above fiber enriched food product.

[0060] Other embodiments of the invention will be apparent to those skilled in the art from a consideration of this specification or practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with the true scope and spirit of the invention being indicated by the following claims.